REMARKS

Claims 1-16 are pending in the application with Claims 1 and 7 being in independent form. In the Final Office Action dated November 24, 2003, Claims 1-6 and 8-10 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over U.S. Patent Application Publication No. 2002/0020919 ("Li et al.") in view of U.S. Patent Nos. 5,939,763 ("Hao et al.") and 6,436,824 ("Chooi et al."). Claims 6 was rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Li et al. as modified by Hao et al. and Chooi et al. in view of U.S. Patent No. 4,123,571 ("Balog et al."). Claims 7 and 11-16 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over U.S. Patent Nos. 6,228,761 ("Ngo et al.") in view of Li et al. and Hao et al.

Independent Claims 1 and 7 have been amended to recite the thickness of the diffusion barrier layer as described, e.g., at page 7, lines 7-8 and 23-24, page 8, lines 18-20, and in cancelled Claim 14.

Independent Claim 1 now recites a "diffusion barrier layer for semiconductor devices, the diffusion barrier layer having an upper surface, a lower surface and a central portion, the diffusion barrier layer comprising: silicon, carbon, nitrogen and hydrogen, with the nitrogen possessing a low dielectric constant being non-uniformly distributed throughout the diffusion barrier layer, wherein the diffusion barrier layer is more concentrated near the lower and upper surfaces and the central portion is substantially devoid of nitrogen, the diffusion barrier layer being between about 7 nm and about 120 nm in thickness."

Independent Claim 7 now recites a "semiconductor device comprising: a substrate containing conductive elements; and a diffusion barrier layer applied to at least a portion of the substrate in contact with the conductive metal elements, the diffusion barrier layer being between about 7 nm and about 120 nm in thickness having an upper surface, a lower surface and a central portion, the diffusion barrier layer comprising silicon, carbon, nitrogen and hydrogen, with the nitrogen possessing a low dielectric constant being non-uniformly distributed throughout the diffusion barrier layer, wherein the nitrogen is more concentrated near the lower and upper surfaces and the central portion is substantially devoid of nitrogen."

Li et al. appears to disclose a diffusion barrier for semiconductor devices, the diffusion barrier including silicon, carbon, nitrogen and hydrogen. Although Li et al. discloses that copper materials are generally surrounded by nitride-comprising materials to prevent diffusion from the copper materials or into the copper materials, Li et al. does not disclose or suggest a diffusion barrier to include nitrogen possessing a low dielectric constant being **non-uniformly** distributed throughout the diffusion barrier layer, wherein the nitrogen is more concentrated near the lower and upper surfaces and the central portion is substantially devoid of nitrogen, as recited in amended Claims 1 and 7 of the present invention.

In contrast to amended Claims 1 and 7 of the present invention, Hao et al. discloses a dielectric layer, having upper and lower regions with elevated concentrations of nitrogen. The ultra-thin dielectric layer of Hao et al. is taught to be thinner than a diffusion layer claimed in amended Claims 1 and 7 of the present invention. Specifically, Hao et al. discloses an ultra-thin dielectric layer having a thickness not substantially exceeding 60 Angstrom or 6 nm, (see Hao et al., column 9, lines 47-49) and discloses no oxide layer thicker than 7 nm. Hao et al. merely discloses a depth of approximately 90 Angstrom near the interface having a peak in nitrogen concentration rather than the thickness of the dielectric layer (see Hao et al., column 7, lines 56-63), but do not disclose the thickness of the dielectric layer with the nitrogen being non-uniformly distributed through the diffusion barrier layer thicker than 7 nm. Thus, Hao et al. does not disclose the diffusion barrier layer being between about 7 nm and about 120 nm in thickness claimed in amended Claims 1 and 7.

Second, Hao et al. teaches a dielectric layer, in which the bulk nitrogen concentration in the layer is less than 10^{18} atoms/cc (see Hao et al. column 7, lines 65-67). In contrast, the present invention recites, in amended Claims 1 and 7, the diffusion barrier layer having a central region substantially **devoid** of nitrogen. Additionally, while Hao et al. merely discloses that incorporation of nitrogen into the thin oxide layer has been shown to inhibit boron diffusion and to improve the Si-SiO_2 interfacial structure to relax the interfacial strain (see Hao et al., column 2, lines 19-31), the present invention discloses the lower surface 14b of the diffusion barrier layer reacts with the conductive elements 12, e.g., Cu, thereby providing greater adhesion of the film to the conductive elements 12 (see page 6, lines 25-29) and the nitrogen-containing upper surface

14a results in a strong adhesion of the dielectric layer 16 onto the diffusion barrier layer 14 (see page 8, lines 4-6). These are substantial differences in composition and/or structure in the diffusion barrier layer claimed in amended Claims 1 and 7 and the dielectric layer of Hao et al.

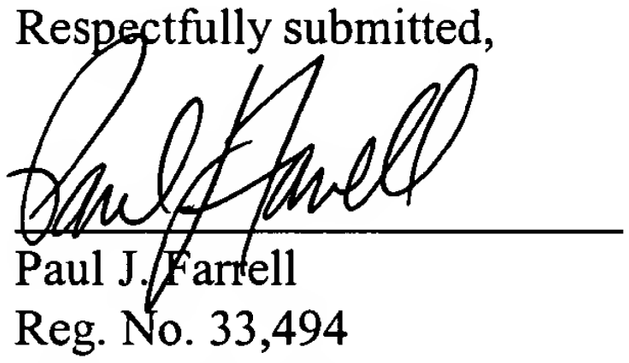
In particular, the advantages provided by the present invention have been substantiated by the comparative testing presented in Example 1 and Comparative Examples 1 and 2. Referring to these comparative test results, the present inventive diffusion barrier layer provides an improved robust adhesion between the interconnection layers while also maintaining a relatively low dielectric constant for a device. In contrast to the present invention, Chooi et al. discloses a diffusion barrier having a low dielectric constant by reacting to the methylsilane with ammonia, but does not disclose the nitrogen being non-uniformly distributed throughout the diffusion barrier layer recited in Claims 1 and 7. It is therefore concluded that neither Li, Hao, Chooi, nor the combination thereof teach or suggest the diffusion barrier layer with the nitrogen being non-uniformly distributed throughout the diffusion barrier layer that is between about 7 nm and about 120 nm in thickness and the central portion is substantially devoid of nitrogen as recited in amended Claims 1 and 7.

With regard to rejection of Claims 7 and 11-16, the Examiner agrees that Ngo et al. does not disclose the nitrogen-rich diffusion layer processing a low dielectric constant and also does not disclose the nitrogen-rich diffusion layer having a thickness between 7 to 120 nm. It can therefore be concluded, in view of the above discussion, that Ngo, Li, Hao, or any combination thereof do not teach or suggest the diffusion barrier layer as recited in amended Claim 7.

Without conceding patentability per se of dependent Claims 2-6, 8-13, and 15-16, it is respectfully submitted that they are allowable by virtue of their dependence on independent Claims 1 and 7 respectively.

In light of the foregoing remarks, it is respectfully submitted that Claims 1-16 are in condition for allowance. Such early and favorable action is earnestly solicited. If the Examiner has any questions concerning this communication or feels that an interview would be helpful, the Examiner is requested to contact the Applicants' Attorney at the number indicated below.

Respectfully submitted,



Paul J. Farrell
Reg. No. 33,494
Attorney for Applicants

DILWORTH & BARRESE, LLP
333 Earle Ovington Blvd.
Uniondale, New York 11553
(516) 228-8484